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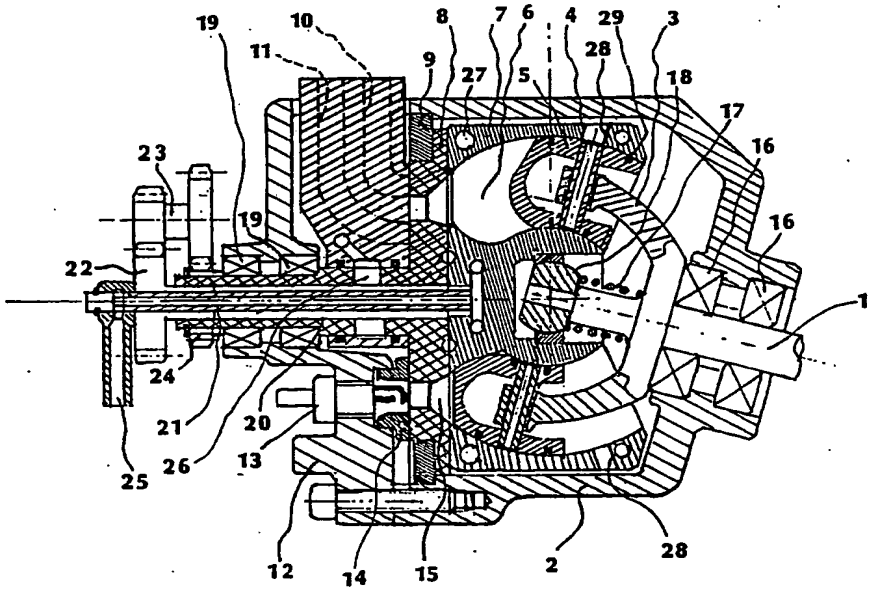

(57) Abstract

The volumetric machine for fluids, endothermic or not, have liners with non-linear or curved development, which are machined, or not, in a rotating liner block (7, 45, 63, 75) on an axis that can be coinciding or passing with the axis of the shaft (1, 37), from the side of its center curvature; the pistons (5, 42, 59, 62) rotate with the liners, but on an inclined axis coinciding with the axis of rotation of the liners or passing through the same center, without the interposition of elements having alternate motion.

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DESCRIPTION OF THE INVENTION

Volumetric fluid machine equipped with pistons without connecting rods.

The invention relates to a volumetric fluid machine, endothermic or not, equipped with pistons, having reciprocating movement in the liner block without connecting rods, rigidly connected to the driving shaft or not, namely a pump, compressor and/or an engine, which can also be endothermic, that while functioning, achieves a displacement by means of pistons connected to the driving shaft without oscillating connecting rods. The displacement can, furthermore, be changed as wished if necessary.

The state of the art in the field of endothermic engines comprises: engines with alternating pistons which are connected to the crankshaft with connecting rods; the volumetric lobe engine (Wankel), with rotor eccentric to the driving shaft, or engines which have axial pistons, i.e. parallel to the driving shaft and driven in the alternating motion with a circular sloped course in order to achieve the axial displacement of the piston and which do not have high performance. In the field of pumps/motors or fluid compressors, both compressible and not, there are various known arrangements of the pistons: in line, mounted axially, either with oscillating barrel or with oscillating plate, or mounted be radially.

However, all above mentioned pistons are connected to the driving shaft with connecting rods, which oscillate on a surface perpendicular to said shaft, or with connecting rods, in the case of axial pistons, which oscillate when running on a conoid surface, because the inclination of course of the big end of the connecting rod has a variation of range, while the small end is driven into the lin-

er by the piston.

The above mentioned mechanisms, except for the endothermic lobe engine (Wankel), have large dimensions, and none have high efficiency which depends on the conditions of utilization.

In particular:

- for the rotary lobe engine (Wankel), the sealing parts have a short life due to the heavy wear to which these are subject, with loss of compression and, therefore, loss of efficiency. The use of special materials is required which are very expensive and difficult to obtain.
- The endothermic piston engines, in all their various configurations, have limited speed of rotation, due to the presence of parts with alternating or oscillating motion, pistons, connecting rods, valves and also the crankshaft, which is always of difficult construction; the axial thrust from the piston is transmitted to the connecting rod by the presence of the reaction of the cylinder wall: this reaction causes heavy wearing and therefore high performance lubricating oils are needed; in four-stroke engines, efficiency is reduced because of the impossibility of designing the combustion chamber in the ideal way due to the dimensions and the restricted passage of the valves.
- As regards pumps/engines for compressible fluids, the disadvantages are the same as those caused by the connecting rods in endothermic engines, with low efficiency due to mechanical friction produced by these connecting rods, and high weight, dimensions and costs.
- As regards pumps/engines for incompressible fluids, typically for hydrostatic trensmissions, but also for the pumping of other liquids, the various disigns, offer distinguishing inconveniences, such as: pumps/engines with radial cylinders or in line cylinders, whilst providing fairly good performance, have large dimensions and high

construction costs; pumps/engines with axial cylinders, are subdivided in the two following categories: cylinders with inclined barrel, as regards the axis of the shaft, or with inclined plate for the guidance of the big end and cylinders which are parallel to the axis of the shaft. Both present inacceptable limitations of speed of rotation, caused by possible centrifugation of the big ends; the second presents very low efficiency at the starting point and also impossibility of working in an open circuit. The diffusion of both has beeen limited by the high construction costs.

Such state of the art may be subject to large improvements as regards: improving the characteristcs of the mechanisms of reciprocating volumetric engines by increasing efficiency in all conditions, reducing weight, dimension and construction costs.

From what has been said so far the technical problem would be solved by eliminating in reciprocating volumetric engines the parts with oscillating motion, typically: connecting rods, valves, the parts that are complex, such as the crankshaft and the camshaft, the same time reducing the dimensions and the weights.

The present invention solves the above-mentioned technical problem by adopting:

a volumetric machine for fluids, including mobile pistons inside liners with non-linear development, which are machined, or not, in a rotating liner block on an axis that can be coinciding or intersecting with the axis of the shaft, from the side of its concavity; the pistons rotate with the liners, but on an inclined axis coinciding with the axis of rotation of the liners or passing through the same center, without the interposition of elements having

alternate motion;

adopting, furthemore: the liners are of arched form and with center of curvature on their axis of rotation, that can be coinciding or passing, in the same center of curvature, as the axis of driving shaft; the pistons rotate in syncronism with the liners, but on an inclined axis coinciding with the axis of rotation of the liners or passing through the same center curvature;

adopting: the variation of the inclination between the axis of rotation of the liner block and of the pistons, in order to obtain the variation of displacement;

adopting: pistons connected in a rigid or oscillating way to their shaft or rotation plate, without the interposition of connecting rods;

adopting: pistons with spherical head, equipped with seal rings which also have spherical faying surface, located in the piston head in such a way as to come into contact with respective liner wall radially with respect to the axis of that same liner;

adopting: the pistons are arched in the same way as the liners and are equipped with seal rings with spherical faying surface.

Adopting in the case of the internal combustion engine: a distribution plate, adjacent to the liner block with at least one communication port to the liners for induction, at least one outlet port and at least one combustion chamber, that rotates or not with respect to the casing;

adopting: on the distribution plate, closed zones in intermediate positions, that coincide with the end position of scavenging fase and thus achieve null volume in four-stroke cycles;

adopting: one single auxiliary cooling and lubricating circuit;

adopting: the liner block as the mobile part of the pump

for the cooling and lubricating circuit.

Adopting, in the case of a volumetric machine for fluids: either the piston-holder plate or the liner block keyed or rigidly connected to the shaft;
adopting: pistons with head connected rigidly to the shank, which is in turn rigidly connected to the rotating plate that can be inclinable, inclined, or not
adopting: oscillating piston heads with contact surface with the shank and contact surface with head of the connecting bolt, also spherical and concentric;
adopting: the variation of the displacement obtained by varying the inclination between pistons and liners, bearing on the plate whose rear surface is a cylindrical surface with axis of rotation that passes through in the same point of intersection between the axis of rotation of the liner block and pistons.

The advantages achieved by the present invention, for all types of volumetric machines for fluids, can be sumarized by the absence of parts with alternating and oscillating motion, such as connecting rods, the traditional pistons and valves: all this leads to a considerable reduction in noise, due to the absence of thrust elements that when oscillating create noise because of the unavoidable presence of clearances between components. The elimination of the radial loading of the pistons on the walls of the cylinder, because the thrust of the fluid is always tangential to the curvature of the liner, which always coincides with the center of the spherical piston, whether fixed or oscillating; consequently there is a considerable reduction in wearing and an increase in efficiency, specially at start-up in the case of volumetric devices; there are fewer parts to be constructed and there is considerable reduction in swarf machining required; consider-

able reduction of the axial and radial dimensions of the machines, for the higher powers and efficiencies obtainable. Particulary, for the internal combustion engines, problems regarding centrifugation or elasticity that can limit speed of rotation are eliminated; moreover, cooling is facilited both of the pistons from the internal part of the casing and of the rotating liner block, which can easily operate as a cooling liquid pump; the restintances and the choking of the valves are eliminated; the lubrication and cooling circuits are not separate, as it is possible to utilize the cooling liquid that has lubrication function too.

Furthermore, particulary for volumetric machines pumps/engines or compressors, compensation of the axial thrusts on the pistons being facilitated, further reduces friction and so increases efficiency; connecting members between the piston-holder plate and the liner block are not required, which on the other hand are obligatory in barrel pumps or engines; the pistons with fixed spherical head connected to the piston-holder are suitable for low or medium angles between the shaft and the inclined element (pistons or liner block) and enable high speeds to be obtained as there are no components subject to centrigfugation. The pistons with oscillating head enable very large angles to be used and enable dimensions to be reduced even with large displacements. The heads, that self-center on the tangent at the line of curvature at any point along the liner ned, therefore, on the thrust of the fluid, do not radially load the liner wall, limiting wearing and increasing efficiency.

Finally, the pumps of the hydraulic circuits can work indifferently in both open circuit and closed circuit at the same speed of rotation, as there are no components of articulated elements (typically connecting rods) that could disconnect and centrifugate; the feeding of the closed

circuit is obtainable also directly without the traditional use of the so called charge pumps; in the combination of more pumps for different hydraulic circuits the pairing of more pumps on one same shaft is easily achieved and with reduced dimensions; each of these pumps is sized and/or adjusted for the particular requirements of the circuit, avoiding the use of expensive mechanical couples.

A few embodiments of the invention are shown in the five drawing tables attached, in which: Figure 1 shows a section of an internal combustion engine, with four pistons and four-stroke cycle, in accordance with the invention; Figure 2 is the side view of distribution plate faced on to the block of rotating liners; Figure 3 is a partial section of an ignition device of a two-stroke engine; Figure 4 and figure 5 are views according to two lateral directions at 90° of the curved piston; Figure 6 is the longitudinal section of a pump/engine or compressor for fluids, with variable displacement in both directions, with rotating and inclinable block of liners. Figure 7 is partial view from the supply side of the plate of inclination and of the distribution of fluid to the block of rotating liners; Figure 8 is the section of a piston with oscillating head; Figure 9 is a longitudinal section of a pump/engine for fluids, the same as Figure 6, but with an inclinable piston holder plate instead of the liner block; Figure 10 and 11 are the same views of Figure 4 and 5 but for a piston not for internal combustion engine; Figure 12 is a side view of a spherical piston; Figure 13 is the longitudinal section of a pump/engine for fluids, the same as Figures 6 and 9, without inversion of motion of fluid; Figure 14 is a longitudinal section of a pump/engine for fluids, the same as the previous Figure with both mechanisms having a variable displacement.

The indications are as follows: 1 (Figure 1) is the drive shaft that rotates on bearings in the casing 2 of the endothermic engine and positioned on each end 3 of the shaft, each of which is coupled with piston pin 4 to the corrisponding curved piston 5; this last piston is driven from the mentioned ends to move inside the liners, which are machined in the rotating liner block 7; with 8 the distribution plate, rotating on the ring 9; with 10 and 11 the exhaust pipe and induction pipe; with 12 the head, equipped with ignition plug 13, which is facing the piston in a position of maximum compression, through an anti-wear ring 14 and the combustion chamber 15, which is machined in the thickness of the distribution plate; with 17 the spring for the recovery of clearances for the sealing between distribution plate 8 and the liner block 7, which bears on the spherical articulation 18 of the centering block of the shaft; with 19 guide bearings of the tube 20 the distribution plate, comanded through internal coaxial shaft 21 rotating with the liner block 7 and through reduction gearing of speed 22,23 and 24; with 26 refrigerating duct of the distribution plate and of the manifold 10 and 11,and with analogous 27 duct in liner block; with 28 a radial hole in each liner for the assembly of the piston pin 4; with 29 the seal rings of the pistons 5, connected to the respective pin boss 30 through the piston pins at each end 3; with 31 and 32 (Figure 2) the holes and the suction ports on the distribution plate and with 33 and 34 the holes and the corrisponding exhaust ports; with 35 (Figure 3) the chamber of combustion in the fixed distribution plate 36 of a two-stroke engine.

In the second embodiment of the invention, the indications are as follow: with 37 (Figure 6) a drive shaft of the pumps/engine or volumetric compressor on which the piston holder plate 39 is splined, by means of a splined

profile 38; the pistons are screwed on to the plate by means of a thread; with 40 the piston shank has a central hole 41 of compensation of the axial hydraulic thrusts, it has a head with a spherical swelling 42 and a seal ring 43 with external spherical swelling; the above mentioned pistons are driven into the liners 44 of the rotating liner block 45, which is driven to the mentioned shaft 37 through a ball joint 46; with 47 the end clearances of the compensation springs acting on the mentioned joint and against the plate 39, which slides against the anti-wear lining 48 to which the compensation cavities 49 of the axial hydraulic thrust are facing; with 50 the hole for the passage of the fluid from the liner to the distribution cap 51, equipped with slots 52 and ports 53, on the side of the liner block 45, which is fed through ducts 54 and 55 for the passage of fluid; with 56 a slot on the axial distribution cap 51 for oscillation, which is driven from the parallel surface, which couples with the housing 58; with 59 the head of the spherical piston, can oscillate on the shank 40 through a spherical headed screw 60 and a corrisponding spherical surface 61 between the shank and the piston head 59.

In the third embodiment of the invention, without repeating the numbers of the common parts found in following Figures, are as follows; with 62 the curved piston, mobile in the liners of the block 63, which has feding holes, facing the cover 65 with feeding lines of the fluid; with 66 a piston holder plate driven from the ball joint 46 and facing a corrisponding inclinable cap 67, with a parallel surface 68, against a block inserted 69 inside the housing 58; with 70 the central axis of a curvature of the liners; with 71 (Figure 10) the seating of the seal ring 43 and with 72 the axis of the piston shank 40.

Lastly, the indications shown are the following: with 73 (Figure 13) a plate which is splined on the shaft 37 by means of a splined profile, and supports two series of pistons, which are connected to the plate and which are opposed to one another, equipped with axial holes 74 for connection of the corrisponding chambers of the liners; with 75 a liner block without feeding lines, rotating like block 45, but diesel cycle, starts the combustion through the special chamber 15 or 35, in the case of two-stroke engines that have the distribution plate fixed to the cylinder head 12; the drive of the coaxial driving shaft 21, together with the gears 22,23 and 24, halve the rotation, because of the distribution plate control 8, through sleeve 20.

During the stroke of the pistons 5 inside the liners 6, the slight differences of path, which are also due to the high angles between the spin axis are compensated by slight oscillations on the gudgeon pins 4 in the hubs 30 besides slight radial slidings of the pistons in the intermediate positions of 45°, 135°, 225° and 315° of rotation. The coolant is sucked from the radiator through the pipe 25 and is conducted into the liner block 7 through the hollow shaft 21; the holes 27 riceive the coolant by means of radial ducts, which are not shown in the drawing, that are situated between the liners: the coolant is therefore centrifugated by the rotation of the liner block and fills the internal volume of casing 2 then hot it flows out into tubes that are not shown in the drawing towards the radiator; the coolant, by means of the cavity wall between the sleeve 20 and the coaxial shaft 21, cools the central part of the distribution plate 8 and with the ducts it also cools the manifolds.

The functioning of the pump/engine or compressor for fluid referred to the second embodiment carried out occurs

in the following way: the fluid under pressure, flowing in the ducts 54 and 55 and crossing the slots 52, the parts 53 and the holes 50, enters the liners 44; the action on the surface of the piston head 42 is distributed with relation to the position of the seal ring 43, i.e. exactly axial to the shank 40, without radial components between the pistons and the liners; the rotation that is imparted to the piston-holder plate 39 is transmitted to the driving shaft 37 by splined fitting 38: the cavities 49, which are held at the same pressure of the liners 44 by the hole 41, balance the axial hydraulic thrusts on the mentioned plate and on the pistons; the Belleville washers 47 close the end clearances between the liner block 45, the cap 51, and the housing 58: the preloading is considerably superior to the force generated during the suction of the fluid at atmospheric pressure. The variation of displacement and, therefore, a major versatility during use is possible by changing the inclination of the cap 51 by sliding on the cylindrical surface 57. The head of the oscillating piston 59, for the employment of large angles between the axis of rotation of the pistons and of the liners with, is always balanced, because the center of oscillation is out of the piston and inside the fluid. On the contrary, usual pistons have the piston pin situaded a considerable distance from the surface in contact with the fluid.

The functioning of the pump/engine or compressor for fluids referred to the third type carried out, occurs in the following way: the keying position to the shaft 37 is inverted: i.e., it is the liner block 63 that drives the couple: this disposition generates a radial component for the piston heads 62, rapidly wearing out the liners. The curved piston with head 62, results to be more adapted for disposition with a high angle of inclination between the axis even if it is more difficult to construct. Also for

this realization, the variation of the displacement obtained with the inclination of the cap, in this case number 67.

Figures 13 and 14 show two realizations for pumps/engines or compressor for fluids, for use in different fields: the first is a pump/engine with one series of pistons of variable displacement and the other series of fixed displacement, without inversion of direction of the fluid; the second is equipped with both series of pistons with variable displacement and inversion of flow, as indicated by the arrows next to the feeding lines 54,55 is possible; the caps 51 and/or 76 are inclined through external control with well known mechanisms. In both two realizations the piston-holder plate 73 keyed on the driving-shaft 37, balances the axial thrust between the opposing liners 44 and with the axial holes 74 being in the pistons, less work is done by the fluid in passing through.

The operation as a pump/compressor can comfortably occur for all the angles of the cap (51 and/or 76), while when functioning as an engine, due to the known impossibility of zero setting the displacement, the angle must not be too reduced. Moreover, with the elimination of the fluid motion between the two series of pistons of the double device in figures 13 and 14, which reduces the efficiency, the displacement in the mechanism of figure 13 must not be completely zeroed: the cap 76 must not be placed with opposed inclination to that figure; the displacement in the mechanism of figure 14 must not be varied by controlling the caps 76 and 51 with inverted sincronism and causing the caps 76 and 51 to become parallel whereby the displacement is zero: they must be inclined as in the drawing or in an opposite way due to ensure flow of fluid in both directions respectively.

If in practice materials, dimensions and operative details should be different from those indicated, but technically equivalent, the patent will still apply.

In this way the pump/engine or compressor in Figures 6 or 9 can be obtained at a fixed displacement, or even a pump and an engine can be paired through cavities 49 or the feed ports 64, by interposing a fixed distributor to the housing, in order to carry out compact hydrostatic drives: the advantages of the reduction in dimensions and weight and of running at high speeds make this type of embodiment extremely interesting.

Finally, fixing the pistons rigidly to the housing and placing the liner block in oscillation by means of axial or radial cam connected to the driving shaft, a pump/engine or compressor, without moving parts will be obtained with exception for the cam: this is very convenient in the case of pumps or engines for liquids. By analogy to the variable displacement pumps, engines or compressors, it is possible to carry out, with the configuration of pistons 5, 42, 59 or 62, and of the rotating liner block 7 of the present invention, endothermic engines, that can reduce their displacement, facilitating the mixing of the fuel with the air, without the complex artifices that are employed at present for the adjustment of its composition, achieving advantageous efficiencies at low charge.

CLAIMS

1. Volumetric fluid machine, endothermic or not, equipped with pistons, having reciprocating movement in the liner block without connecting rods, rigidly connected to the driving shaft or not, including mobile pistons inside liners, characterised in that the liners have a non-linear development, which are machined, or not, in a rotating liner block (7, 45, 63, 75) on an axis that can be coinciding or intersecting with the axis of the shaft (1, 37), from the side of its concavity; the pistons (5, 42, 59, 62) rotate with the liners, but on an inclined axis coinciding with the axis of rotation of the liners or passing through the same center, without the interposition of elements having alternate motion.

2. Volumetric fluid machine, according to claim 1, characterised in that the said liners (6, 44) are of arched form and with center of curvature on their axis of rotation, that can be coinciding or passing, in the same center of curvature, as the axis of driving shaft (1, 37); the pistons rotate in syncronism with the liners, but on an inclined axis coinciding with the axis of rotation of the liners or passing through the same center curvature.

3. Volumetric fluid machine, according to one or more of the previous claims, characterised in that the variation of the inclination between the axis of rotation of the liner block (7, 45, 63, 75) and of the pistons (5, 42, 59, 62), allows the variation of displacement.

4. Volumetric fluid machine, according to one or more of the previous claims, characterised in that the pistons are connected in a rigid or oscillating way to their

shaft (1, 37) or rotation plate (39, 66, 73), without the interposition of connecting rods.

5. Volumetric fluid machine, according to one or more of the previous claims, characterised in that the pistons have a spherical head (42, 59), equipped with seal rings (29, 43) which also have a spherical faying surface, located in the piston head in such a way as to come into contact with respective liner (6, 44) wall radially with respect to the axis of that same liner.

6. Volumetric fluid machine, according to one or more of the previous claims 1 to 4, characterised in that the pistons (5, 62) are arched in the same way as the liners (6, 44) and are equipped with seal rings (29, 43) with spherical faying surface.

7. Volumetric fluid machine with internal combustion, according to one or more of the previous claims, characterised in that it has a distribution plate (8), adjacent to the liner block (7) with at least one communication port (31, 32) to the liners for induction, at least one outlet port (33, 34) and at least one combustion chamber (15), that rotates or not with respect to the casing (2).

8. Volumetric fluid machine, according to the previous claim, characterised in that distribution plate (8) has closed zones in intermediate positions, that coincide with the end position of scavenging fase and thus achieve null volume in four-stroke cycles.

9. Volumetric fluid machine, according to one or more of the previous claims 7 and 8, characterised in that it has one single auxiliary cooling and lubricating circuit.

10. Volumetric fluid machine, according to one or more of the previous claims 7 to 9, characterised in that the liner block (7) act as the mobile part of the pump for the cooling and lubricating circuit.

11. Volumetric fluid machine, according to one or more of the previous claims 1 to 6, characterised in that either the piston-holder plate (39, 66, 73) or the liner block (45, 63, 75) is keyed or rigidly connected to the shaft (37).

12. Volumetric fluid machine, according to one or more of claims 1 to 6 or 11, characterised in that it has pistons with head connected rigidly to the shank (40), which is in turn rigidly connected to the rotating plate (39, 66, 73) that can be inclinable, inclined, or not.

13. Volumetric fluid machine, according to one or more of the previous claims, characterised in that the oscillating piston heads (59) with contact surface (61) with the shank (40) and contact surface with head (60) of the connecting bolt, also being spherical and concentric.

14. Volumetric fluid machine, according to one or more of the previous claims, characterised in that it has variable displacement obtained by varying the inclination between pistons and liners, bearing on the plate (51, 67, 76) whose rear surface is a cylindrical surface with axis of rotation that passes through in the same point of intersection between the axis of rotation of the liner block (45, 63) and pistons.

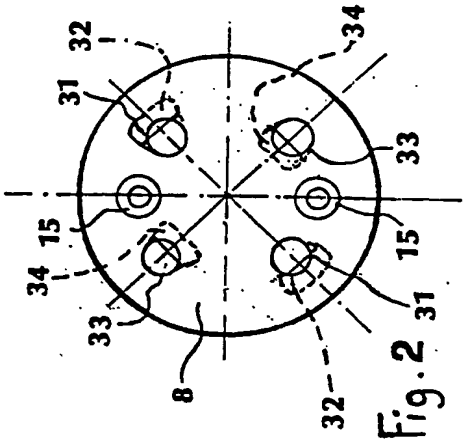

Fig.2

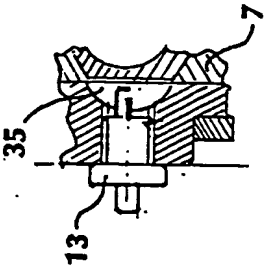

Fig.3

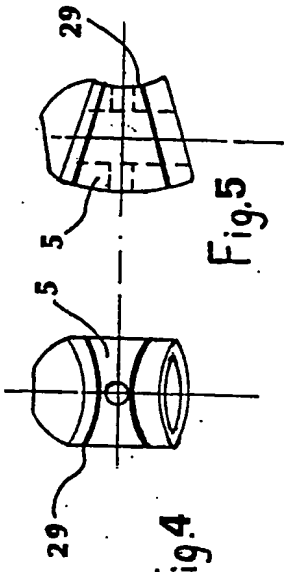

Fig.4

Fig.5

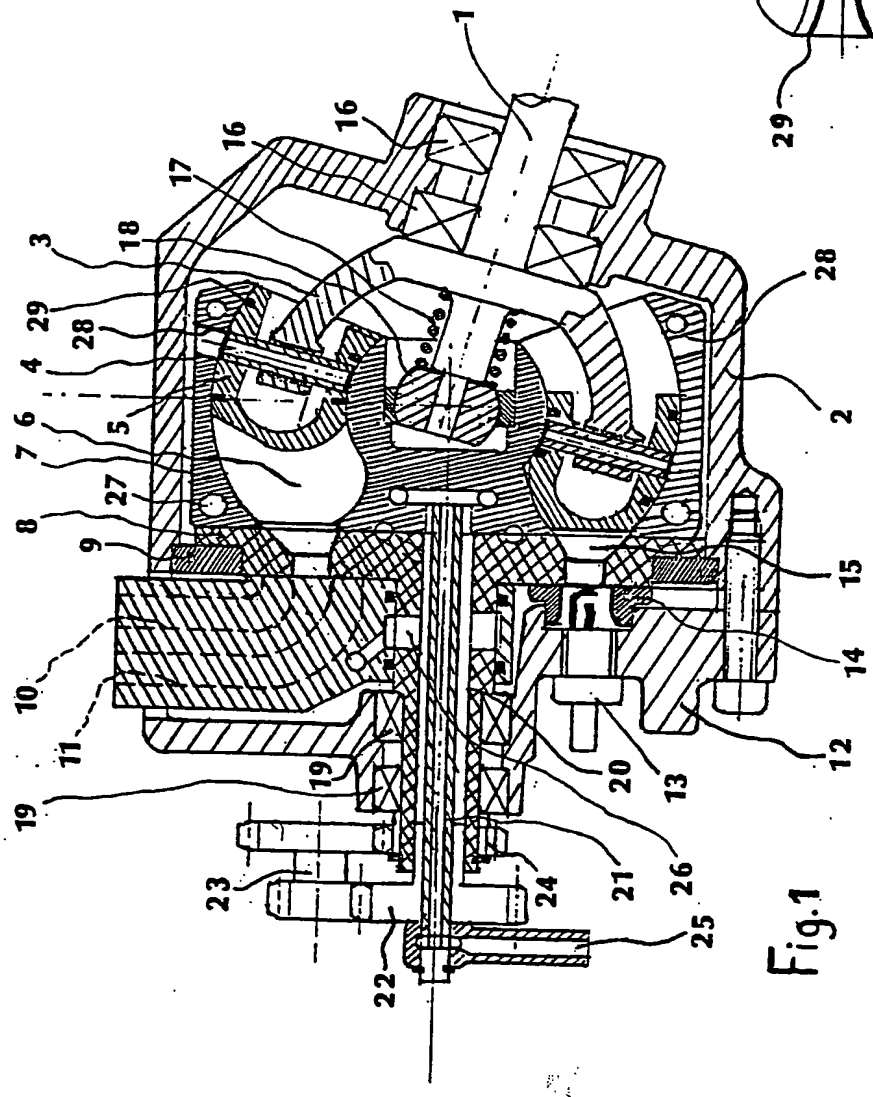

Fig.1

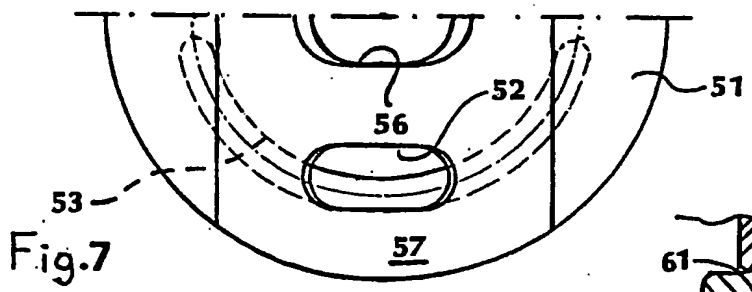

Fig.7

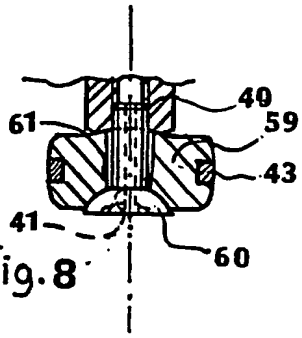

Fig.8

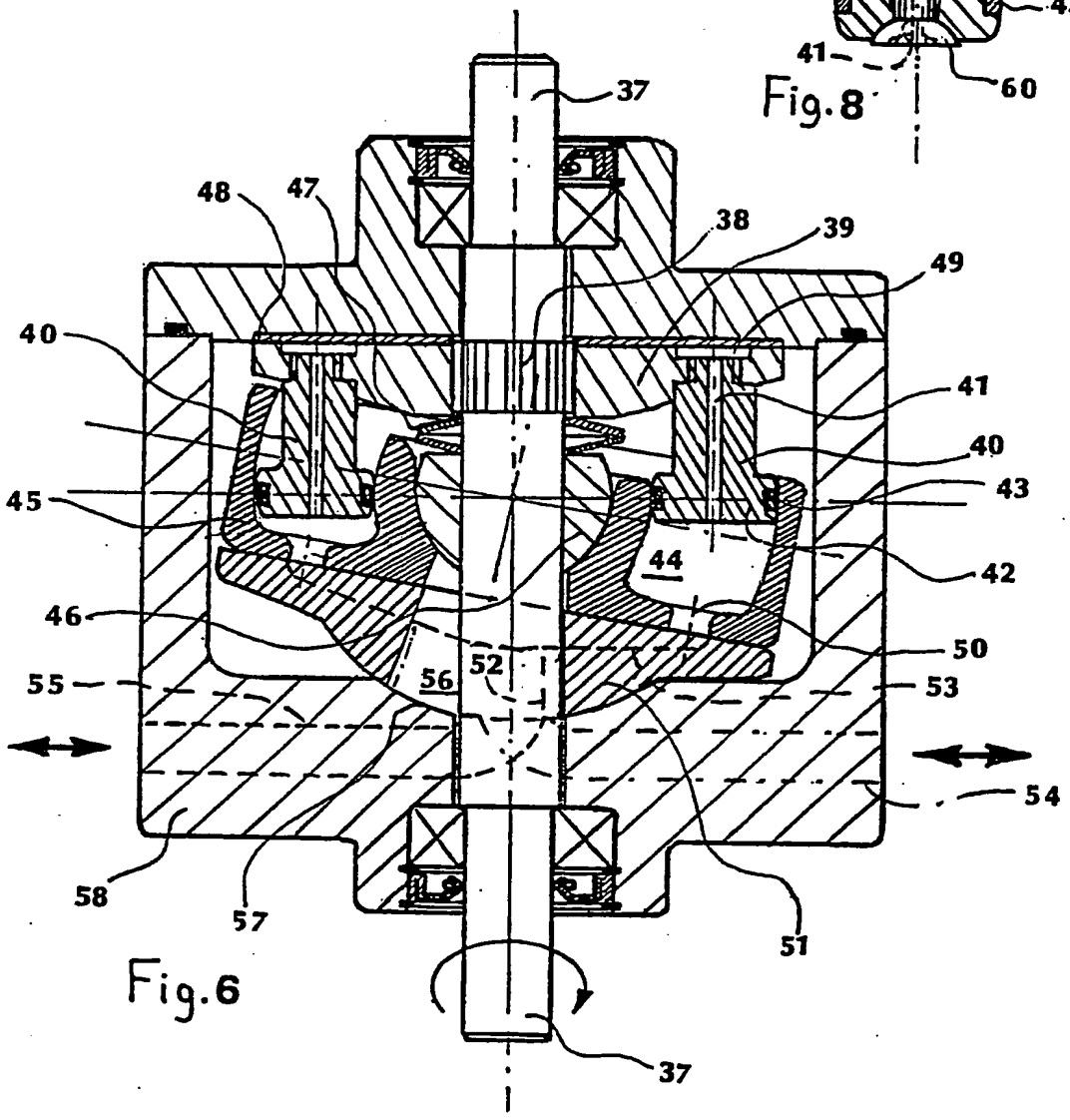

Fig.6

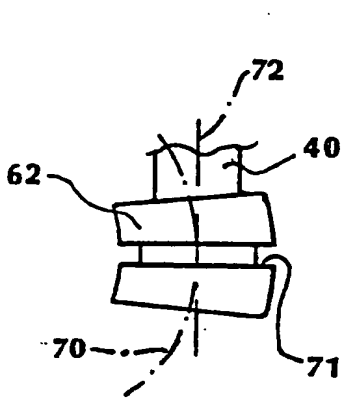

Fig.10

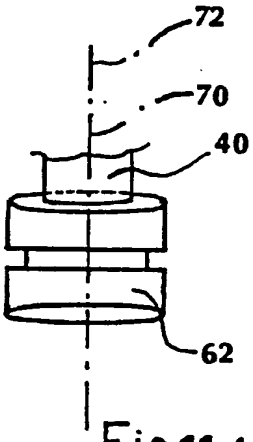

Fig.11

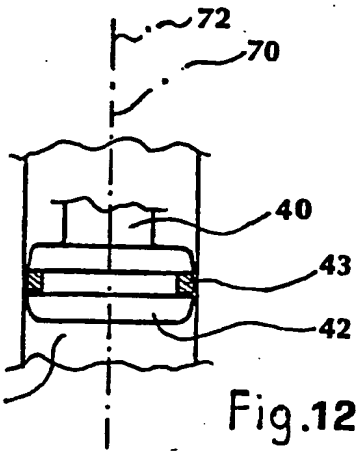

Fig.12

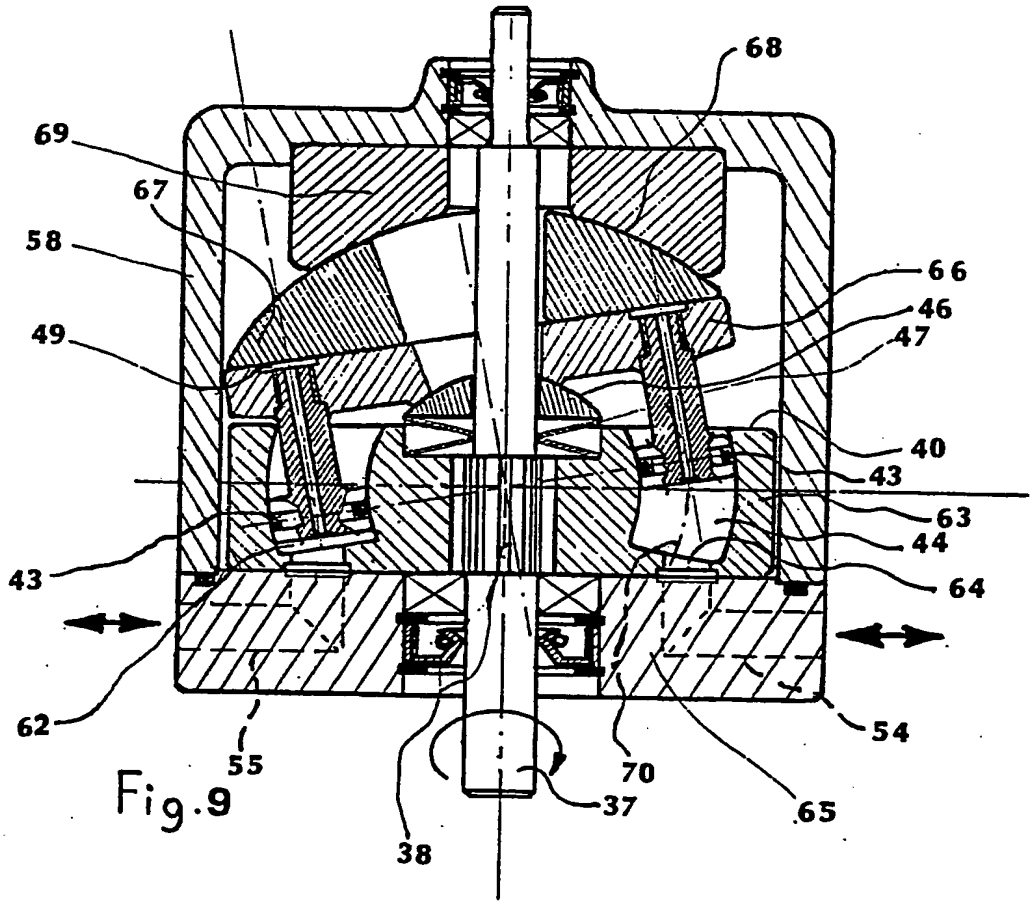

Fig.9

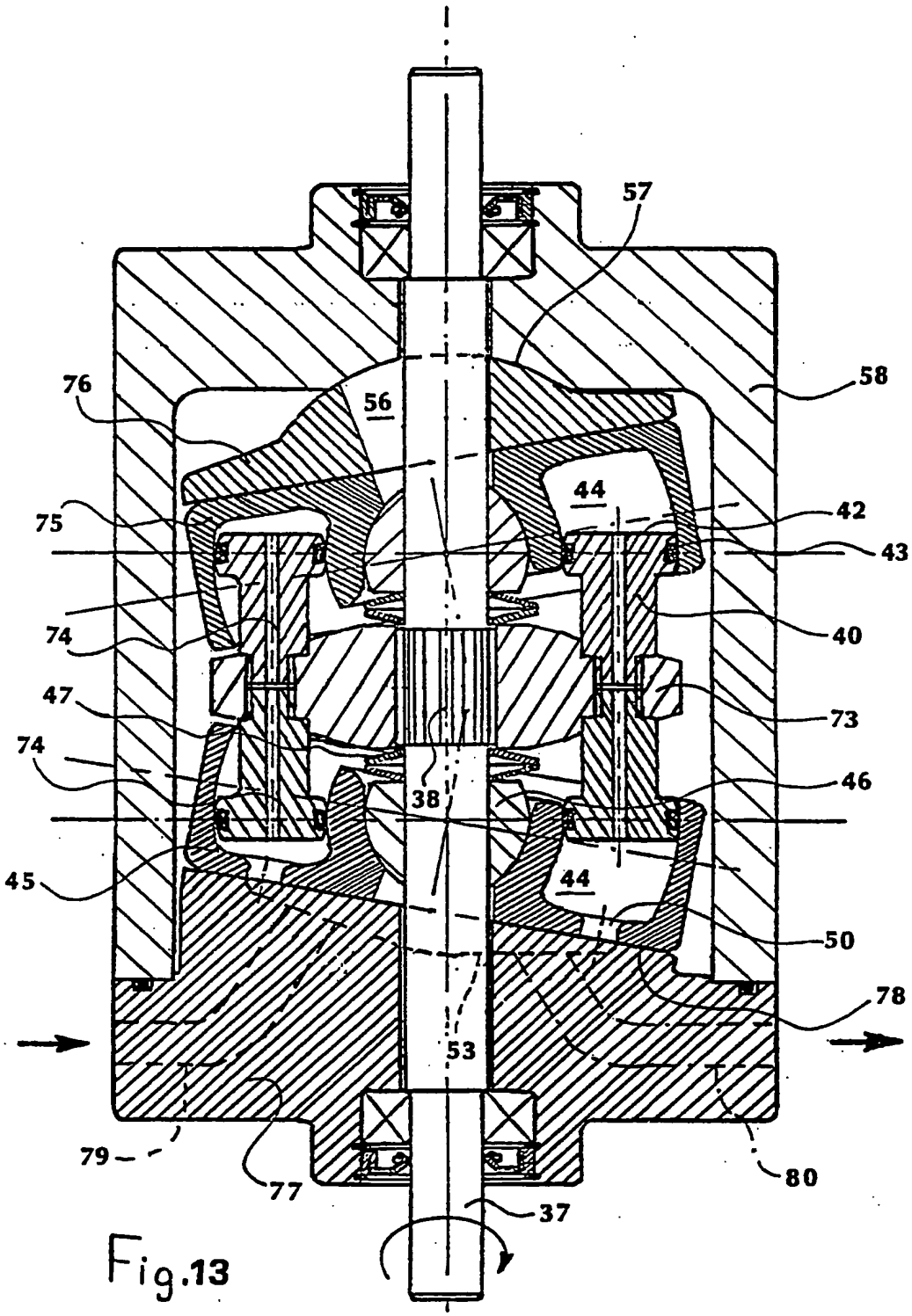

Fig.13

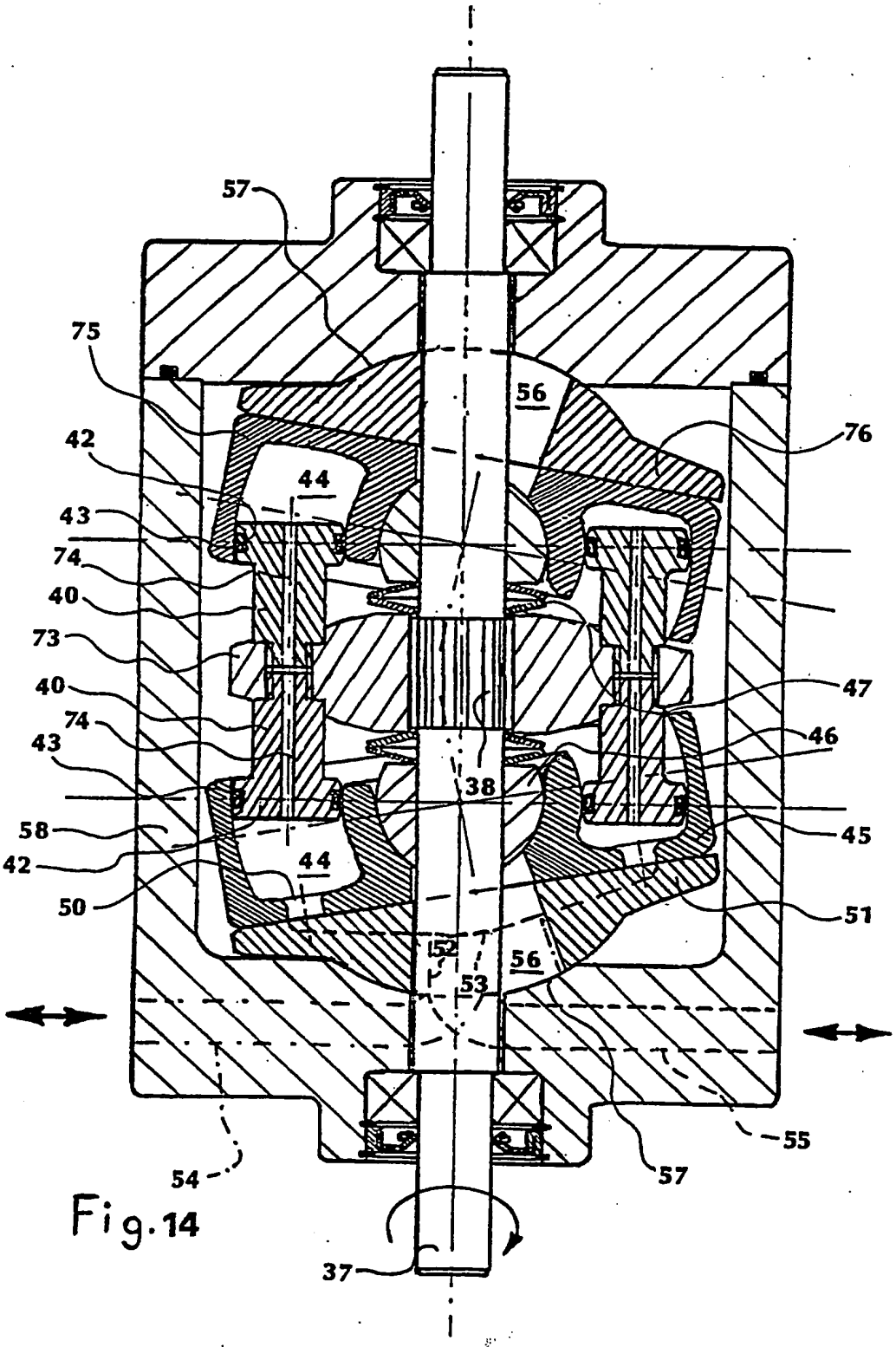
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Fig. 14

INTERNATIONAL SEARCH REPORT

Interr. al Application No
PCT/IT 93/00113

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F04B1/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 F04B F03C F01B F01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO,A,86 00662 (SEARLE) 30 January 1986 see abstract; figure 1	1 3-5, 11-12,14
Y A	US,A,3 910 239 (JAMES) 7 October 1975 see abstract; figure 1	1 2,6
A	FR,A,1 408 719 (CHAYVIALLE) 7 February 1964 see abstract; figures	1,3-4, 11,13-14
A	US,A,3 648 567 (CLARK) 14 March 1972 see abstract; figures	1,3-5, 11-12,14
A	GB,A,2 027 122 (SEARLE) 13 February 1980 see abstract; figures 1,6	1,7

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 January 1994	21. 01. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Narminio, A

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INTERNATIONAL SEARCH REPORT

...formation on patent family members

Inten ...al Application No
PCT/IT 93/00113

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP-A- 51010205	27-01-76
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FR-A-1408719		NONE	
US-A-3648567	14-03-72	NONE	
GB-A-2027122	13-02-80	NONE	